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HIGH VOLTAGE[1]

By Dr. KARL T. COMPTON

PRESIDENT OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

WHILE there is much truth in the statement that necessity is the mother of invention, it has often been pointed out that it is far from true that necessity is the mother of discovery. Discoveries come often most unexpectedly, in the pursuit of knowledge by the curious and observant. The great background of natural phenomena which have thus been discovered form an immense reservoir from which may be drawn natural laws or combinations of phenomena which can be made to work for the solution of men's needs or desires when necessity arises.

One of the most excellent examples of the fact that necessity is the mother of invention is found in the great number of applications of science which were made during the past war to cope with situations which never before had challenged the ingenuity of man. Such situations were the detection and location of submarines or of airplanes flying by night. There were also the location of underground mining operations or of enemy artillery by sound, or the direction of counter-battery artillery fire, also by sound. Such examples could be multiplied almost indefinitely, but the interesting feature of them all is that every one was handled by the application of some scientific phenomenon which had been known in the laboratory for many years. The necessities of war brought forth the means of applying these phenomena for particular purposes.

It is to a very recent example of this natural sequence of events that I will call your attention tonight, an example taken from the field of electricity, the chosen field of Joseph Henry, in whose honor this lecture has been named. It is a modern application of one of the oldest branches of electricity, a branch so old that some ultramodern text-book writers have advocated omitting it entirely from text-books

[1] The third Joseph Henry lecture delivered before the Philosophical Society of Washington on March 11, 1933.

on account of the academic and impractical character of its subject-matter. But let me first lay the groundwork for this new development in the field of high-voltage electricity.

While electricity can be produced in a variety of ways, and it was some time in the history of the subject before it was realized that the electricity was the same kind of thing in all these cases, nevertheless there are but three principal means of generating electricity. The first is static electricity, first discovered by Thales of Miletus as early as 600 B. C. Thales found that amber, when rubbed against other substances, had the power of attracting fragments of straw or leaves or feathers. In fact, the word electricity is derived from the Greek word electrum meaning amber, and was first so used by William Gilbert in about 1600.

The second great step in the production of electricity was the invention by Volta of the Voltaic cell in 1799, and from that time until the time of Faraday in 1831, the great development of electricity was in the production of batteries of various kinds. Volta was able to generate several hundred volts by piling up alternate layers of copper and zinc, separated by paper which had been moistened with acid, thus creating, in effect, a battery with a large number of cells in series.

When in 1831 Faraday made the discovery of electromagnetic induction and about the same time Joseph Henry discovered self-induction and independently repeated a number of Faraday's discoveries in mutual induction, the modern science of electricity and art of electrical engineering were born.

It is a striking fact, which perhaps we do not stop to think about, that this so-called electrical age has grown up during a period of one working lifetime, since men like Elihu Thomson are still living and men like Edison have just died, who built upon these scientific discoveries of Faraday and of Henry the modern art of electrical engineering.

With the development of electromagnetic devices, dynamos, motors and transformers, the use of batteries except for very special cases has largely been discontinued. Static electricity, which had been developed from the study of frictional charges and charges of conductors by induction, was relegated almost to the field of scientific but useless curiosities. The efficiency of electromagnetic generating apparatus has been developed to a remarkable degree, so that, for the practical purposes of our industrial needs and our home needs, the modern science of electricity has appeared to be eminently satisfactory.

It is true that there have been some other new developments of first importance in the electrical field, notably electronic devices, such as radio tube detectors, amplifiers and transmitters or devices which operate with ionization of gases, such as the mercury-arc rectifier and the glow discharge tube. These things, however, are more in the nature of electrical instruments or electrical control devices and it still remains true that the production and distribution of electricity are basically carried on by means of the electromagnetic induction devices developed from the work of Faraday and Henry.

Let us first follow the development of high voltage by electromagnetic induction. In this as in all other fields the first developments were crude, as was necessarily the case because instruments and methods had not been developed and everything had to be taken up *de novo*. When Joseph Henry wished to build his great magnet with several coils of wire, he had first to invent insulated wire, which he did by wrapping strips of his wife's dresses and petticoats with shellac around the wire. When Henry wished to measure the voltage of the current produced in a step-up transformer, he had no ammeter or voltmeter capable of detecting the small current at high voltage and had to substitute for them the students in his class, judging the voltage by the number of students who could be shocked when connected hand to hand in series across the terminals of the secondary of his transformer. Thus a voltage that would shock thirty students he estimated to be twice as high as one which would shock fifteen students, and in this way he was able to arrive at a very crude but correct idea of the relationship between the number of turns of wire in the secondary of a transformer and the voltage which was produced therein.

The story is told of a striking lecture demonstration given by Henry while at Princeton. He hung a secondary coil of a large number of turns of wire on the inside wall of his classroom and had the students of his class join hands in series across the terminal of the coil. The primary coil of this transformer was concealed from the students, being suspended on the outer wall of the building from wires passing out through an attic window and connected with a large Voltaic battery in the attic. When Henry rapped against the wall his assistant in the attic plunged the copper and zinc battery plates into the acid, thus sending a current through the primary, which induced a high voltage in the secondary and shocked the students of his class.

It is probable that Henry, burdened as he was with administrative duties and the difficulties of finding the means wherewith to carry on his experiments, did not realize so clearly as did his contemporary, Faraday, the ultimate practical value of these things which he was doing. Faraday, when once asked by the King, "What is the use of these things?" replied, "Your Majesty, of what use is a baby?" And another time when he was asked by the Prime Minister

this same question, "Of what use are these things which you are doing?" he replied, "Your Excellency, some day you may be able to tax these things." Henry, however, was so wrapped up in his scientific pursuits that he gave little thought to the possible practical application of his work. It is said that when he was once urged to press his claim as inventor of the telegraph and other instruments, he replied that there were far too many interesting things to be done in the laboratory to permit him to take time with such matters.

There has been a practical urge for the development of high voltage power from three different points of view. The first and most important of these is for the transmission of electric power over large distances. It is much more economical to transmit power at high voltage and small current than at low voltage with large current because the resistance losses depend upon the current and not the voltage. For this reason, the voltage of high power transmission lines has continually risen from first a few hundred volts, then a few thousand, not many years ago sixty thousand, and now upwards of two hundred thousand volts. The losses of power due to heating of the wire from the flow of current are such that, according to a practical rule, it is not economical to transmit electrical power farther than one mile for every thousand volts. From this we see that a modern two hundred thousand volt transmission line could be economically used to transfer power from the power generating station to distances of about two hundred miles, but beyond these distances such transmission of power is not economical. For that reason, in any area requiring the use of electricity, power generating stations must be located at distances of not more than two hundred miles from each other.

The question may be asked as to why the voltage is not raised still higher than two hundred thousand volts, and the answer to this is found in the fact that with higher voltages the electric field in the air surrounding the wire becomes so intense as to ionize the air, causing a leakage of electricity from the wire into the air in the form of an electric discharge known as a corona. It is this phenomenon of corona which sets the practical upper limit to the voltage which can be used for transmission.

It is not feasible to generate directly voltages in the range of several hundred volts because the difficulty of insulation becomes too great, and an electric dynamo with insulation adequate to withstand even several thousand volts would have to be so large, to include the necessary insulation, as to be unwieldy and inefficient. Consequently, the power is generated at relatively low voltage, usually a few hundred volts in alternating current and this is sent through a step-up transformer insulated in oil in which the secondary has a hundred or a thousand times more turns of wire than the primary. In this secondary coil the very high voltage is generated for transmission over the power lines. Then at the other end of the line the power is fed through a similar transformer in the reverse order and comes out of that secondary as a very large current at relatively small voltage.

There has been no really fundamental difficulty to be overcome in these power transmission lines, although there have been very many interesting problems of science and engineering to be solved. The proper design of a transformer to be efficient and to be sufficiently well insulated is one problem. Perhaps the most difficult problem has been that of proper switching devices so that these high-voltage currents can be started and stopped without excessive arcing at the switches. It is such developments as these which have made the great generating stations at Niagara Falls and the many other hydroelectric or steam-electric generating stations such an important feature in our present industrial life.

The second thing which has stimulated high voltage developments of the electromagnetic type has been the x-ray. For ordinary purposes, from thirty thousand to one hundred thousand volts are adequate for either diagnostic or therapeutic purposes. Of recent years, however, in the endeavor to find the most effective methods of treating internal cancerous growth there has been an increasing desire to go to much higher voltages, and consequently x-ray tubes operating on as much as a million volts have been developed at the General Electric Company, at the California Institute of Technology and elsewhere.

To generate the high voltage power for these x-ray tubes, recourse has been had to transformers connected in series, the primary of one transformer being connected with the secondary of the other, and all transformers after the first being insulated. By such means, large power can be delivered and high voltages obtained, although a million volts appears to be about the practical limit because there are parasitic currents known as charging currents which drain a great deal of energy uselessly from the system when an alternating or varying current is used at such high voltages. Furthermore, the equipment becomes tremendously expensive on account of the requirements for insulation.

The third thing which has led to high voltage developments of the electromagnetic induction type has been the study of the effect of lightning on transmission lines and the desire of electrical engineers to duplicate as nearly as possible the effect of lightning by means of high-voltage sources for laboratory study. For this purpose there has been developed the impulse generator, in which a series of condensers capable of storing electric charge at high voltage are charged in

parallel from a high-voltage transformer and are then connected in series so that the overall voltage which is delivered is the sum of the voltages across the separate condensers. By such means impulsive or momentary voltages of ten or fifteen million volts have been obtained. These are exactly right for studying transient effects like those of lightning, but the impulse generator is inherently incapable of serving properly any purpose which requires a steady and reasonably constant source of high voltage. The discharge in this impulse generator lasts only a few hundred thousandths or millionths of a second.

This impulse generator represents the peak of high voltage accomplishment by the electromagnetic method, and you will notice that this is accomplished by combining with the electromagnetic device, namely the step-up transformer, a series of condensers which are essentially electrostatic instruments.

Let us return now from the high-voltage developments, based on principles of electromagnetism, to the historically earlier type of electric generation which falls within the general field known as electrostatics. The characteristic of these devices has been the relative ease of producing high voltages, but with an exceedingly minute quantity of electricity.

The first electrical machines of which we have any knowledge were frictional electrical machines constructed about 1663 by Otto von Guricke. They consisted of globes of sulfur made to rotate about an axis so as to rub against the hands of persons held against them. In this way the globe of sulfur became electrically charged and the charge of the opposite sign appeared on the person who touched the globe. Isaac Newton appears to have been the first person to use a glass globe instead of sulfur, but it was Ramsden in 1768 who really constructed the first object which might really be called an electrical generating machine.

The Ramsden machine consists of a glass plate which can be rotated by a winch, and which passes with rubbing contact between two leather pads. By friction the glass becomes positively charged and the pads negatively charged. These positive charges are taken off the glass disk as it passes in rotation between combs of sharp points. Similarly, the negative electricity from the pads is collected from them and delivered to another terminal. For a number of years the only development of the art of electrical generation consisted in finding various materials which might be put on the glass or on the leather pads to increase their effectiveness in separating frictional electricity.

A later development of a frictional machine is that invented by Lord Armstrong, of Newcastle, England, in 1841. Lord Armstrong was experimenting with steam boilers. By accident one of his assistants received an electric shock when he touched a piece of metal against which a jet of steam from a leaky boiler was striking. This led Lord Armstrong to further experiments leading to the steam electrostatic generator. The action of this generator consisted in blowing drops of condensed steam, by the steam pressure, out through a series of nozzles against a neighboring metal plate. The droplets of water were charged by frictional contact against the walls of the nozzles. The electrical power was created by the work done in moving the charged droplets against the electric field which developed between the nozzle and the plate on which the droplets struck, and of course this power was in turn derived from the driving power of the steam which carried the droplets out and away from the nozzle.

Another whole series of electrostatic generators was built upon the principle of electrostatic induction. Perhaps the simplest of these was the Belli doubler, which was devised in 1831 and operated on the same principle as a later device designed by Lord Kelvin and better known as the Kelvin Replenisher, described by him in 1872. This action is shown schematically in Fig. 1. When the rotating member with the insulated plates E and F is at the position shown, positive and negative charges are separated from the connecting wire, which brushes lightly against E and F, by means of the electrostatic forces arising from the charges on the neighboring metal armatures C and D. As the rotating arm turns and breaks contact with these brushes the charges are carried on E and F and, when they touch the springs C and D, respectively, these charges are communicated to the armatures, thus increasing the charge already existing on these armatures. Then at the next contact with the brushes at E and F the process is repeated. Consequently, the charge on the armatures continually builds up until it reaches such magnitude, or rather until the voltage rises so high that the charge leaks away as fast as it is produced, leaking away either through the insulation or by a corona discharge produced by breakdown of the surrounding air.

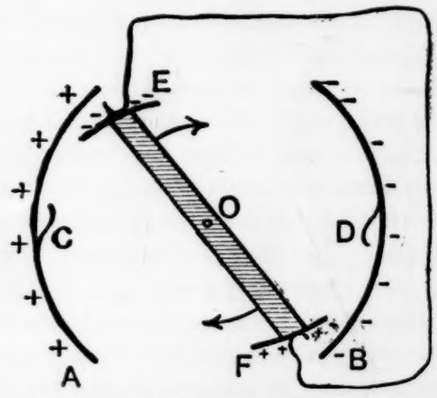

FIG. 1. Schematic diagram of Kelvin Replenisher

A large variety of instruments, some simple and some very complicated, have been developed to carry on the idea of the Belli doubler in a more efficient manner. Such devices were devised by Varley in 1860, by Toepler in 1865 and by Holtz between 1864 and 1880, but by far the most successful of these devices is the well-known Wimshurst machine, which was first invented in about 1878. This machine is well known to everybody, I think, as the "influence machine" whose action may be described as follows:

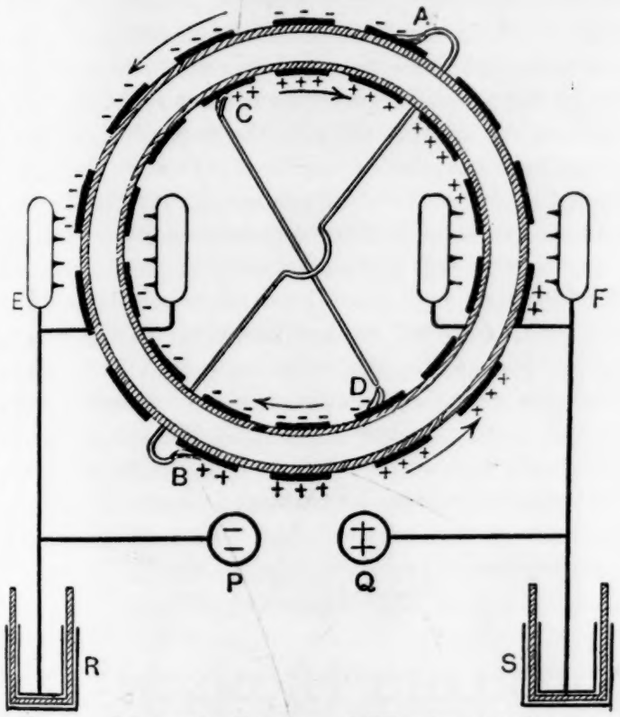

FIG. 2. Schematic diagram of Wimshurst influence machine

Imagine that, in some way or other, such as by friction, a small negative charge is located on the metal sector of the rotating disk opposite the point *C* of Fig. 2. This negative charge will induce the separation of positive and negative electricity in the metal rod *CD*, drawing positive charge to the point *C* and forcing negative charge to the point *D*. At these two points the charges are collected on the metal sectors of the second glass disk which is rotating in the opposite direction. Thus all the metal sectors to the right of *C* carry positive charge collected from *C* and they all deliver it to the sharp needle point at *F*.

At the same time, these positive charges on the metal sectors to the right of *C* will similarly induce negative charges in the metal rod *AB*, which charges will be deposited on the metal sector to the left of *A* and will in their turn be collected by the sharp point at *E*. Thus the process is a continuous one, *E* and *F* collecting negative and positive electricity, respectively, from the metal sectors on both of the revolving disks. By having a multiplicity of revolving disks these Wimshurst machines may be made to deliver a considerable amount of power and were in fact at one time quite largely used in the x-ray art until they were supplanted by the more powerful and much more convenient electromagnetic induction devices described previously, including step-up transformers, induction coils and the like.

One of the most ingenious types of electrostatic induction machines is the famous Kelvin water-dropper, which is shown in Fig. 3. Here perhaps more easily

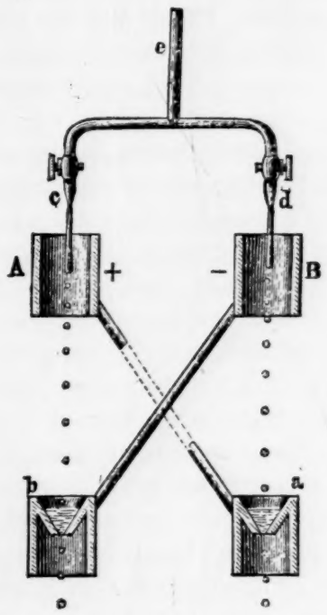

FIG. 3. The Kelvin water-dropper

than in any of the other induction machines can be seen the way in which a small charge once produced may result in the continual building up of an indefinitely large charge, if the arrangement of apparatus and connections are suitably arranged. Assume for a moment that for some cause, such as friction of the wind or anything else, there happens to be a small charge on the cylinder *A*. Every drop of water leaving the outlet in *A* will therefore carry a small induced negative charge which will be delivered to the cup below, thus raising the cylinder at *B* to a negative charge. All the drops of water which come from the outlet inside of *B* will therefore carry the positive charges which will be collected in the trap below and serve still further to increase the positive charge on *A*. So the process goes on, the charges building up until through leakage or through a corona discharge to the air, they leak away as fast as produced.

At this point I am minded to make a confession regarding my first experiment in physics. I conceived the idea of producing electrolysis by the use of gravitational energy alone, and set up a device somewhat similar to the Kelvin water-dropper. My device consisted of drops of copper sulfate coming from an

outlet like that in the cylinder *A* and falling into a platinum funnel like that directly below *A*. I charged the cylinder *A* with a large negative charge from a static machine and this charge remained on the cylinder, which was well insulated. Consequently, every drop of copper sulfate which dropped carried an induced positive charge and delivered it to the funnel *b*, which was earthed. This excess positive charge would of course be in the form of copper ions which would be deposited on the platinum in the process of neutralization of the drop. After running the apparatus for an hour or so, I looked at the platinum cylinder to see whether I could see any copper deposited on its inside and finding none I set the apparatus going in the late afternoon and let it run automatically until the following morning. Again examining the funnel, I found no deposit of copper and, somewhat surprised, I sat down to figure. I soon discovered that the copper would be present in far too small a quantity to detect. In fact, if every drop were charged with the largest amount of electricity which it could carry without losing it by corona to the surrounding air, and if the drops had fallen as fast as possible beginning with the time of Christ, I would by this time have collected barely enough copper to be shown by the most sensitive known chemical test. This little experience illustrates the vast difference in magnitude between the kind of currents that we are accustomed to deal with in electromagnetic induction devices, dynamos and motors, and these relatively very feeble currents of electrostatics. These drops were charged with high electrostatic voltage and the device was a fairly efficient electrostatic generator, and yet two thousand years would have been required to deposit an amount of copper such as would appear in a fraction of a second with only a moderate current of the type which we ordinarily use in electromagnetic instruments.

In recent years an interesting development of the Kelvin water-dropper has been proposed by Dr. Swann, of the Bartol Research Laboratory, in which the water drops are replaced by steel balls which fall under the action of gravity, and in order to make the process continuous, there is the suggestion whereby these balls may be carried back again to the upper container by means of magnetic control. In this way, the succession of falling balls behaves somewhat like a continuous belt containing metal sections separated by insulated regions of air and driven by gravity. In the absence of leakage this kind of a generator should be capable of developing such a high voltage that the electrostatic attraction of the falling balls would just compensate gravity. This would be an extremely high voltage such as could be obtained only if the apparatus were operating in a vacuum, and in fact Dr. Swann suggests that it may be operated in this manner.

(To be concluded)

IN HONOR OF PROFESSOR ELIHU THOMSON

By Dr. HARVEY CUSHING

I HAVE been requested to speak in behalf of the professions other than Engineering. This is embarrassing for a doctor, for though Medicine has been said to be the mother of the sciences, they have usually left her, when grown up, to make their own independent way in the world. The best she can do under the circumstances is to breed more; and being prolific, this she continues to do. Meanwhile, being busily engaged in what is more an Art than a Science, she scarcely pretends to know how her scientifically minded descendents have grouped themselves, much less what mischief they are up to under their individual names.

There are those twins, for example, that have just been here, one terrestrially minded, the other stratospheric—but just which one is Auguste and which one Jean she is not quite sure. And then there are the Comptons whom she has learned to differentiate as H. V. and C. R.—High Voltage Compton and Cosmic Ray Compton—and this, after all, is not so difficult for her to remember. But when it comes to identifying all the Elihus, mostly surnamed Thomson but sometimes Thomson-Houston, that's another kettle of fish altogether.

What may be the relation of E.W. (Electric Welder) to E.L. (Electric Lighter) to C.T. (Current Transformer) to P.T. (Power Transmitter) to Q.F. (Quartz Fuser) and to Aurora B. and M.I.T. Thomson, to mention but a few of them, it's now impossible for almost any one to say. To one of this superfluous lot, sometimes known as H.F.A.C. Thomson, mention will subsequently be made if advancing time and contracting space permit. The only thing known about the Thomsons as a clan is that in memory of Roger Bacon's tutor, Peter Perigrinus, who is the family saint, every newborn child cuts his teeth on a loadstone or a spool of wire or both at the same time, and as a consequence the continued activity of the U. S. Patent Office is easily explained.

[1] Address at the dinner given in honor of Dr. Elihu Thomson on the occasion of his eightieth birthday, at the Massachusetts Institute of Technology, May 1, 1933.

Who the original three-coil and biphase Thomas or Thom may have been whose sons have so often inherited these same spool-of-wire tendencies is unrecorded, but I strongly suspect the gene is traceable to that particular lowland valley which breeds more natural philosophers and engineers to the square inch than any other—namely, the valley of the Clyde, whence Manchester can be reached in what for a Scot is a mere two days' walk. But these sons of the first Thomas have scattered farther afield than that, and it doesn't take a paleontologist to identify specimens in most remote parts of the world.

Even in such a surprising place as Woburn, Massachusetts, there cropped up a certain Benjamin who during a life dedicated to the relation of heat and friction, changed his name to Rumford, established the Royal Institution, picked out Humphrey Davy to run it, and found it more comfortable to abide there with him than to keep house with Lavoisier's widow, who proved too frictionable even for Benjamin. Another who similarly changed his cognomen was William of Glasgow, simply bursting—as would be expected from his chosen place of nativity—with heat, electricity and magnetism; but in course of time, in order to differentiate himself from his no less gifted and highly charged brother James, he felt obliged to adopt the name of Kelvin.

And there was Charles Wyville of the Challenger deep-sea expedition, Jocelyn Home the electrical engineer, James the mathematician, James Park the geographer, Robert who first made use of india rubber for tyres, and Thomas the chemist, and John Miller another, and Joseph John of Cambridge whose son George Paget of Aberdeen could not be pacified with a spool of wire so he was taught to pass electricity through gasses instead. And later on the same (now Sir) J.J. discovered a small negatively charged particle in the atom—with which the speaker at this moment feels in perfect accord. In short, there appear to have been no end to these Thomsons—and when they weren't natural philosophers, they were poets or musicians or something else—even doctors.

Still, I strongly suspect that after all there may not have been so many of them as would appear. For they may well enough have assumed different names when variously occupied. And this may conceivably account for all these local Elihus who some day may come to be conveniently expressed in a single formula—such, for example, as Baron of Lynn and Swampscott. This suggestion at least was made both by Count Rumford and Lord Kelvin when they passed their family medals on to him. And when Michael Faraday in turn bequeathed his medal to the Elihu of a given epoch, he admitted privately that his own name was Thomson back on the distaff side; for how else could he legitimately have come by that easily recognizable spool-of-wire gene?

And not to be forgotten in this genealogical survey is the late Sylvanus P., who is more addicted to p's than most Thomsons, but the fact that he produced sundry technical works on electricity including a treatise on dynamo-electric machinery and the electromagnet, beside writing a life both of Faraday and of Kelvin, serves unmistakably to identify him with the clan. The reason he should not be overlooked by the representative of the professions other than engineering, who chances to address you, is because he has taken pains to point out that the sire of the twin sciences of electricity and magnetism happened to be a doctor.

For William Gilbert of Colchester, Physician to Queen Elizabeth and much else, was almost the first to cultivate the method of experiment and reasoning from observation. He has been justly called the Father of Electric Science for his discovery that the power of a loadstone could be augmented by "arming" or capping it with soft iron, which he called the *armatura*. And after a life-time of experiments, just 333 years ago, and shortly before his death from the plague, he finally published the results of his studies in that epochal book in which the novel idea was first advanced that the globe of the earth is itself a great magnet. And while he spoke of electrifiable bodies as *electrics*, it was another doctor, Sir Thomas Browne, who for the first time forty-six years later coined and used the word *electricities*.

So the mention of Sylvanus P. Thompson brings us back again to Medicine, the mother of the sciences, and to a certain High Frequency Alternating Current Thomson already mentioned. That this might be the same Thomson under some other initials to whom Medicine was already in debt for his contributions a generation ago to the new science of Röntgenology seemed likely enough. But as there was some uncertainty about this, a letter was addressed to H.F.A.C. Thomson, Esq., of Lynn, Massachusetts, telling him that he might be interested in the application of various cutting, dehydrating and coagulating currents to the art of surgery, more particularly as facilitants to operations on the brain.

The sender ventured to say that he ordinarily did not permit laymen to witness operations. Only once had this rule knowingly been broken, in the case of the poet, Walter de la Mare, who was curious to see what the living brain of a conscious patient looked like when exposed to view. No wheels or bats were demonstrable in that particular attic, only a tumor, and the poet, while politely attentive, had shown by his attitude a certain measure of disappointment in what resembled a vascularized piece of dough.

But the electrical engineer who was partly responsible for what is called electro-surgery might well feel differently about it, and he was welcome to have a private look if he desired. The letter was returned from Lynn saying that there was no H.F.A.C. Thomson there any longer. There was a Q.F. Thomson who was busy squirting molten quartz on a mirror and who said he didn't recall H.F.A.C's address—only knew him slightly and never thought much of him anyhow.

So you can easily see how difficult it is for a person "representing all the other professions" to speak intelligently and authoritatively of the manifold and shifting interests of an electrical engineer, particularly when his name is Thomson—as it usually is and always should be—and more especially when he alternates from one field of research to another with such astonishingly high frequency. And also how embarrassing it is for an after-dinner speaker to realize that one of these Elihus—quite possibly the one here—not only is familiar with more types of gas than will be turned on to-night, but also invented the first muffler or silencer which by this time he probably wishes he'd brought with him.

But when we actually come to fuse all these Thomsons of our immediate vicinity and to get a composite picture of them, it becomes quite evident that the resultant Elihu is one of those rare men who transcend their own chosen walk in life and who belong to us all. It is not their genius alone which is responsible for this, however rare a gift genius may be and however much it may be envied and admired. It is only when genius is combined with those equally precious qualities of modesty, unselfishness and simplicity—the imponderables of high character and lovable personality—that there emerges from the common herd, from time to time, an occasional man whose life symbolizes for the rest of us, whatever be our profession, something as nearly perfect as one could hope to attain in this fallen world.

A HISTORY OF THE NATIONAL RESEARCH COUNCIL 1919--1933

VI. DIVISION OF MEDICAL SCIENCES[1]

By Professor STANHOPE BAYNE-JONES
CHAIRMAN

WHEN the National Research Council was organized in 1916 the medical sciences were at first represented by two committees: one on Medicine and Hygiene, and one on Research. These committees, like the National Research Council in general, constituted a part of the Division of Science and Research of the Council of National Defense. In February, 1918, a Medical Division was organized in the National Research Council.

During the war the division promoted and aided some forty investigations of industrial and medico-military problems. Although the division had certain funds at its disposal, chief reliance was placed upon the volunteer services of investigators, who patriotically devoted their efforts and facilities to research on problems of immediate interest in connection with the nation's conduct of the war.

After the war, in December, 1918, the division anticipated that its future functions would be: to take part in the correlation of research, to further research directly through grants obtained for the support of selected investigations, to aid the Army, Navy and Public Health Service in the solution of medical problems, and to promote the study of problems of industrial medicine. During the past fourteen years, the actual work of the division has been along the first two lines of anticipated activity. Since the Army, Navy and Public Health Service are provided with their own facilities and have qualified investigators on their staffs, they have not brought their problems to the division. Nevertheless, close and mutually beneficial relations have been maintained between these Services and the Division, providing a valuable exchange of information and a channel for cooperative endeavor whenever the need for it arises. The investigation of problems of industrial medicine and hygiene has not figured as largely in the activities of the Division as was anticipated.

The membership of the Division of Medical Sciences has been composed of the representatives of some fifteen scientific societies in the field of medicine and six or eight members at large. Through them the scientific medical organizations of the country have had a voice in the deliberations of the division and have had a direct influence upon its activities. This relationship with organized associations of scientists has been an important factor in the life of the division.

[1] This is the sixth of a series of ten articles prepared to describe briefly the nature of the activities with which the National Research Council has been engaged during the past fourteen years.

The following persons have served as chairmen since the establishment of the division in 1918:

1918 —R. M. Pearce
1919–1920—Henry A. Christian
1920–1921—George W. McCoy
1921–1922—Victor C. Vaughan
1922–1923—Frederick P. Gay
1923–1924—C. M. Jackson
1924–1925—Ludwig Hektoen
1925–1926—Victor C. Vaughan
1926–1927—Ludwig Hektoen
1927–1928—Howard T. Karsner
1928–1929—William Charles White
1929–1930—Ludwig Hektoen
1930–1931—Edmund V. Cowdry
1931–1932—W. H. Howell
1932–1933—Stanhope Bayne-Jones

Aside from funds for certain salaries and administrative expenses in Washington, the division has no independent source of income. The funds administered by it, under the authority of the National Academy of Sciences, have been received through the Council from donations made by foundations or individuals for specific purposes.

Research projects approved for sponsorship by the division have usually been placed under the charge of special committees. In forming such a committee it has been the custom to enlist the services of the best qualified men in the country, whether or not they happened at the time to be members of the division. This committee then takes charge of the formulation of detailed plans of research, preparation of budgets, allocation of funds to investigators, preparation and issuance of reports and other matters. The committee serves as the active agent of the division and from time to time is called into conference to review and reformulate the work in progress.

During the past fourteen years 29 special committees, in charge of as many different projects, have been established under the division. Some of these committees were never able to function because no funds were obtainable for their work. Others, appointed for advisory purposes, completed their work in the preparation of a needed report. It is apparent from the record that when adequate funds have been available the committees thus supported have been successful in their undertakings. The character of the work done by the division through the financially supported committees is indicated in the following brief reports:

The division was instrumental in securing a fund for the maintenance of the American Type Culture Collection of Bacteria after its transference from the American Museum of Natural History to the Army Medical Museum and thence to the John McCormick Institute for Infectious Diseases in Chicago. At present the division has no connection with the continued maintenance of that collection, but appreciates the valuable services which the collection has rendered to students of bacteria in universities and institutes and to the industrial users of bacterial cultures.

Through a joint committee with the Division of Biology and Agriculture support was obtained for the establishment and work of a commission on the standardization of biological stains. A permanent commission, now functioning independently of the National Research Council, has been of great service to the users and manufacturers of dyes.

Investigation of problems in dentistry has not secured any considerable support through the division. Valuable reports, however, have been prepared on the relation of oral infection to nephritis and on a survey of the field of dental research.

At the request of Dr. Hubert Work, Secretary of the Interior in 1925, a committee of the division prepared for the department a report and plan of investigation of the therapeutic value of the waters of Hot Springs, Arkansas. Although the investigation was not carried out, due to a lack of appropriation of funds, the study given this project by the division was an example of the cooperation with the Federal Government in which the Council and the division were glad to participate.

The division has always had an interest in the study of the effects of climate upon health. During nearly eight years a committee, originally organized in the Division of Biology and Agriculture, considered this subject. Finally funds were secured which made possible a statistical investigation of the daily mortality in New York City in relation to the weather. Another Committee on Climate and Health, recently formed, has not yet obtained the funds needed for its work. The division continues to have a keen interest in physiological climatology and hopes to be able at some time to be of service in the advancement of knowledge of the obviously profound but as yet unmeasured effect of climate upon the welfare and characteristics of human beings.

A joint committee with the Division of Anthropology and Psychology, supported by a small fund, advanced the more general acceptance of a uniform nomenclature of blood groups by giving its support to the Landsteiner or international classification.

For more than ten years the division has been associated with medical, veterinary and bacteriological investigations of undulant fever in man and infectious abortion in swine and cattle. The work has been conducted by a joint committee in cooperation with the Division of Biology and Agriculture. A Central Brucella Station, now semi-independent of the Council,

has been in operation for some time at Michigan State College. Numerous investigations have been made of the bacteriology and chemistry of the organisms in the Brucella group, a collection of cultures of these organisms has been maintained, and a number of publications have been issued. The division would be glad to have the opportunity to expand the program of investigation of undulant fever in man.

A series of publications useful to state and municipal governments and to universities and medical schools has been issued by the division's Committee on Medicolegal Problems. These reports have dealt with workings of the coroner system in this country, the statute laws of coroners and medical examiners, a survey of the law concerning dead bodies, the possibilities and need for the development of legal medicine in the United States, and a report on departments of criminology in our universities. These reports bring together information not previously assembled. They provide a basis for new legislation and new medicolegal education.

After a period of cooperation with the Division of Anthropology and Psychology in the formulation of a very extensive program for the study of deafness and the education of the deaf, the division established a Committee on the Physical Causes of Deafness. During four years the members of this committee and their associates examined 5,000 deaf children. They have published the statistics in two reports, which throw new light upon many of the problems of deafness in children. The reports contain indications of the direction which future investigations might follow to obtain interesting scientific results and an amelioration of the unhappy condition of deaf children. The extension of the studies to include deafness acquired by adults would be highly desirable.

The division has recognized the need for investigation of infections of the nasal sinuses which are responsible for distress and disability in both children and adults. During three years a Committee on Nasal Sinuses has been engaged in this work. In spite of inadequate financial support, this committee has made valuable contributions to the mechanism of ciliary activity, the effects of salt solutions and disinfectants upon ciliated epithelium and the manner in which bacteria and particles are swept from cavities lined by ciliated cells.

A Committee on the Microbiology of the Soil, working in cooperation with the Division of Biology and Agriculture, has undertaken an investigation of the fate of the avian tubercle bacillus in the soil. At present this committee has only small financial resources at its disposal, but it is hoped that support may be obtained to permit it to continue its broadly conceived investigation of the cycles, changes or general fate of pathogenic microorganisms in natural environment outside the animal body.

During the past two years the division has been associated with the Army Medical Museum and clinical societies in the maintenance of an American Registry of Pathology. Case histories, gross and microscopic specimens and photographic material have been collected, chiefly in relation to certain tumors. The results of these collections and summaries and the illustrative material have been made available to surgeons.

Through the efforts of the Committee on Medical Problems of Animal Parasitology an extensive and valuable survey of ascariasis in children has been made in some of the Southern states. The results accomplished have been of real benefit, directly and indirectly, to public health work in this country. State sanitary organizations are continuing along the lines indicated by the findings and practises of this committee.

In January, 1929, a Committee on Drug Addiction was established in the division. The objectives of this committee have been to discover, if possible, a substitute for morphine free from habit-forming properties and to improve the treatment of chronic morphine poisoning and drug addiction in man. Two centers of research have been established, one at the University of Virginia for analytical and synthetic chemical investigation, and one at the University of Michigan for pharmacological testing of substances prepared at the chemical center. In its activity this committee has adopted with success the plan of deliberately establishing and supporting centers for special investigation. It has already greatly increased the knowledge of the chemistry and pharmacology of morphine and its derivatives, of synthetic compounds with possible narcotic and analgesic properties, and is rendering a very general service to alkaloidal chemistry in the United States. With recently renewed support the committee is continuing these studies and is beginning to investigate the problems of drug addiction in man. Throughout its work the committee had had the cooperation of the Public Health Service. The support, assistance and participation in this work given by federal agencies concerned in the narcotic problem in the United States have been invaluable and provide the most advantageous possibilities for future accomplishments.

During the past ten years a large and well-endowed committee of the division has been very active in conducting research in problems of sex. This committee has supported numerous researches, particularly at certain centers where problems of significance in this field were under investigation by competent workers. One evidence of its accomplishment is the publication

during this period of about 500 scientific papers reporting results of work supported by the committee, and a notable recent book on the relation of internal secretions to the phenomena of sex. These researches have played a very important part in the extraordinary advance in our knowledge of reproduction, particularly as regards the sex hormones, which has taken place in the last few years.

Since June, 1922, 198 fellowships in medicine have been granted by the Medical Fellowship Board of the division. The holders of these fellowships have studied in institutions in this country and abroad. According to information obtained by direct inquiry, among 179 past fellows, 154 are now engaged in various forms of teaching and research, mostly in medical schools.

Through the division the Council's Committee on Grants-in-Aid has made 58 grants to individual investigators for research on problems of medical interest. These grants, of relatively small amounts, have supplemented provisions for research at numerous institutions. By encouragement and financial aid they have made possible the initiation or advancement of investigations in the pre-clinical as well as the clinical fields of medicine.

SCIENTIFIC EVENTS

SURVEY OF THE INDIAN OCEAN

A CORRESPONDENT of the London *Times* writes that the plans of the John Murray Expedition, which is to make a survey of the bed of the Indian Ocean, are approaching completion, and Colonel Sewell, until recently director of the Zoological Survey of India, is to settle the final details. The chief difficulty before the committee which is arranging the expedition on behalf of the trustees of the late Sir John Murray was to find a suitable vessel of the trawler type.

An essential feature of modern oceanographical exploration is echo-sounding, the depth of the ocean floor as the ship proceeds on her course being read off in the chartroom. Most available vessels proved quite unsuitable, but the difficulty has been solved by the friendly action of the Egyptian Government in proffering the loan of *The Mabahiss,* a vessel expressly built for fishery investigations. She is a trawler of about 140 feet, with her engines set well aft, built in 1929, and she is to go into dock at Alexandria in July to be fitted with echo gear. The University of Cairo is also undertaking the chemical analyses of the surface waters obtained by the expedition, and is sending two research students to help the British scientific staff in their work.

Captain Mackenzie, formerly of *The Discovery,* is to command *The Mabahiss,* and the sounding gear and all survey work is in the charge of Lieutenant-Commander Farquharson, R.N., who has been seconded by the Admiralty. The other officers and crew will be drawn from the Egyptian service. On the scientific side Colonel Sewell will be assisted by four biologists, of whom two will be mainly concerned with the physical and chemical conditions of the deeper water layers of the Indian Ocean, and two with the zoological side.

The Mabahiss will be commissioned in August, and according to present plans will go direct to the Gulf of Aden, an intensive study of the waters and depths of which will be made. Thence she will run a traverse off the Arabian coast to Karachi, taking water sections and trawling at selected stations. The next cruise will be in the Gulf of Oman.

The second part of the expedition will be mainly concerned with the southern areas, where the Antarctic waters flow to the north and the Indian Ocean waters commence that flow which is farther south known as the Agulhas current. The area south of Sokotra and Cape Guardafui will probably demand particular study, for here during the south-west monsoon are strong currents and confused seas as bad as found in any ocean. Aden should be reached in May, and from thence a direct course will be set to Ghardaga, the marine station of the University of Cairo, and so to the Suez Canal and Alexandria.

The University of Cairo proposes to use *The Mabahiss* in 1934–35 for a national expedition in the Red Sea. She will employ the same methods and gear as on the Murray Expedition, so that all results will be strictly comparable.

FELLOWSHIPS OF THE CHARLES A. COFFIN FOUNDATION

FELLOWSHIPS to nine graduates of technical schools and colleges for the academic year 1933–34 were recently awarded by the Charles A. Coffin Foundation, established by the General Electric Company. The men and the institutions in which they will carry on post-graduate research work, under the terms of these fellowships, are:

Samuel N. Alexander, Oklahoma City, and Philip Nudd, Hampton, New Hampshire, at the Massachusetts Institute of Technology.

William H. Pickering, Los Angeles, and Jesse E. Hobson, Marshall, Indiana, at the California Institute of Technology.

C. Irving Bradford, Newport, New Jersey, and Earl A. Long, Charlotte, North Carolina, at the Ohio State University.

Edward G. Pickels, Richmond, Virginia, at the University of Virginia.

William J. Warren, Arcata, California, at the University of Illinois.

Milton G. White, Sacramento, at the University of California.

The work mapped out by these fellowship recipients is in every case highly technical, and ranges from a study of the scattering of cosmic rays, to be carried on by Mr. Pickering under Dr. Robert A. Millikan, to the effects of the invisible corona on the electric properties of rubber-insulated cable, the problem which is to be attacked by Mr. Warren. The fellowship granted to Mr. Pickering is a renewal, the original having been awarded a year ago.

Such fellowships have been granted by the Charles A. Coffin Foundation annually since 1922, when the foundation was created by the board of directors of the company for the purpose of assisting deserving college graduates in post-graduate work, of recognizing the achievements of electric power and electric railway companies, and of rewarding employees of the General Electric Company who advance the efficiency of the company or contribute by meritorious work to progress in the electrical arts.

The committee which determined the awards comprised Gano Dunn, representing the National Academy of Sciences; R. A. Seaton, representing the Society for the Promotion of Engineering Education, and H. P. Charlesworth, representing the American Institute of Electrical Engineers. This committee was assisted by Dr. W. D. Coolidge, director of the General Electric Research Laboratory.

THE FOURTH CONGRESS OF THE INTERNATIONAL SOCIETY OF SUGAR CANE TECHNOLOGISTS

As the name indicates, the International Society of Sugar Cane Technologists is an organization of those investigators in the different sciences who devote their attention to the advancement of that portion of the sugar industry which depends on sugar cane. The society was formed in Honolulu in 1924, and including the meeting there it has held four congresses at intervals of about three years. The other meeting places have been Havana, Cuba, 1927; Soerabaia, Java, 1929, and San Juan, Puerto Rico, 1932. The society now has 589 members.

The proceedings of the fourth congress have now been issued. The book is imposing in size and the size of the volume does not belie the importance of the papers found between the attractive gray covers. Every branch of the cane sugar industry is undoubtedly represented, and the papers come from tropical and subtropical countries the world around. Besides general sessions, there were held meetings of the five sections, which consist of "Diseases of Sugar Cane," "Agronomics," "Varieties," "Factory Operation and Chemical Control" and "Insect Pests." Many of the papers are illustrated.

The book is divided into two parts, "Proceedings" and "Communications to the Congress." The latter consists of the 129 papers or "bulletins" which were presented. Each has its individual pagination, which is unfortunately rather confusing, but there is a complete table of contents with headings such as "Virus Diseases," "Technique of Field Experiments," etc.

The volume is printed as a "House Document" of the Government of Puerto Rico. It is dedicated to the Commissioner of Agriculture and Commerce, the Honorable Edmundo D. Colón. It is edited by Dr. Jaime Bagué, of the Department of Agriculture and Commerce. Dr. F. W. Zerban, of the New York Sugar Trade Laboratory, was general chairman of the Puerto Rico congress, and Mr. A. H. Rosenfeld, now of the Egyptian Ministry of Agriculture, was general secretary. Mr. M. A. del Valle, of Central Constancia, was assistant secretary. The various persons responsible for this volume are to be congratulated on their excellent work.

One of the resolutions recorded in these proceedings is of general interest. This is that "sugar cane" should be spelled as two words, not as one word or as two words connected by a hyphen.—*T. E. Holloway.*

PROPOSED GRANTS FOR SCIENTIFIC RESEARCH FROM THE PUBLIC WORKS BOARD

IT is reported by Science Service that a share of the $3,300,000,000 public works fund is being sought by government bureaus in order that the harm to scientific research work from "economy" cuts may be mitigated. Secretary of Commerce Roper has announced applications for grants to the Public Works Board that include: for the Bureau of Standards, $450,000; the Bureau of Mines, $275,000; the Bureau of Fisheries, $1,072,474; the Coast and Geodetic Survey, $3,500,939, and the Bureau of Lighthouses, $2,355,068. These funds are sought for "new projects" and if obtained it is expected that members of the scientific personnel furloughed for reasons of budget bureau "economy" slashes will be put back to work.

It is unofficially estimated that about half the 380 employees of the Bureau of Standards whose pay stopped on July 1 might be allowed to continue their work if the appropriation of $450,000 is granted by the Public Works Board.

The Bureau of Standards was affected severely by deductions of the budget bureau from the appropriations of 1934, it being allowed only $1,363,000 instead of the sum of $2,000,000, approximately, which was appropriated by the Congress. The Bureau of Standards is expected to play an essential part in the public works construction program by testing the

materials purchased. If this work can not be done on account of lack of funds, there is the possibility that the government will lose millions of dollars due to inferior materials being used by contractors.

Essential safety work and fundamental research for the mining industry of the Bureau of Mines will be rescued if the funds are granted to that bureau. Similarly, it is contemplated that the coastal mapping and triangulation work of the Coast and Geodetic Survey can be speeded up with employment of engineers and other technical men now out of work owing to the depression. The Bureau of Fisheries sees possibilities of serving the public good by expansion of its fisheries conservation and propagation work.

Applications have also been filed by Secretary Roper for public-works funds for reconditioning projects: Aeronautics, $487,500; the Coast and Geodetic Survey, $79,200; the Bureau of Fisheries, $230,000; the Bureau of Lighthouses, $2,283,920; navigation and steamboat inspection, $30,000; the Bureau of Standards, $148,500. These funds will be for repairing and modernizing buildings and equipment and are not expected to aid materially in salvaging scientific research.

Although no formal applications have been made by Secretary of the Interior Ickes for public works funds for carrying on some of the curtailed activities of the Geological Survey, such grants may be sought. Secretary Ickes has announced his determination to attempt to secure work for furloughed employees of his department with some of the new agencies of the government.

The effect of the economy program on the many research projects of the Department of Agriculture is not yet known. Changes are being made slowly and it may be several weeks before the details will be known. It is known that Secretary Wallace is determined that the scientific research of the department shall not be disrupted.

THE CHICAGO MEETING OF THE AMERICAN CHEMICAL SOCIETY

AT the meeting of the American Chemical Society, which opens on September 10 at the Chicago world's fair, there will be a banquet to honor those who attended the chemical meeting in 1893. *Industrial and Engineering Chemistry* points out that it is notable that those whose careers began at an American Chemical Society meeting at a world's fair forty years ago, when chemistry was but meagerly represented, can again gather at a world's fair where science is the keynote, and where the gains of forty years in chemical science and in chemical appreciation are so unmistakably shown by the character of the exhibits and by the place of honor given this branch of knowledge.

The following men now living are known to have attended the meeting of the American Chemical Society in 1893: W. D. Bigelow, A. W. Burwell, Pontius Conradson, F. B. Dains, Moses Gomberg, G. A. Goodell, C. H. Herty, William Hoskins, H. A. Huston, Louis Kahlenberg, J. B. Lindsey, K. P. McElroy, C. E. Munroe, W. A. Noyes, C. L. Parsons, C. L. Reese, George W. Rolfe, Ludwig Saarbach, A. H. Sabin, F. T. Shutt, H. E. Smith, Alfred Springer, Julius Stieglitz, A. L. Winton.

Should there be omissions from this list it is requested that Gustav Egloff, 2120 Straus Building, Chicago, be notified. The veterans of 1893 will be the guests of the Chicago Section on this occasion.

Four distinguished chemists from abroad will be guests of the society during its meeting. *Industrial and Engineering Chemistry* gives brief sketches of these men, directing attention to their principal interests and achievements:

GEORGE BARGER is fifty-five years of age and is the first occupant of a chair of medical chemistry in the University of Edinburgh. This chair was founded in 1919. He is an organic chemist who has devoted himself especially to the study of substances of biological and pharmacological interest. He prefers clear-cut results to speculation, and is most interested in the determination of the constitution of natural substances, and its confirmation by synthesis (of late years thyroxine, methionine, various alkaloids). Professor Barger is a corresponding member of various European academies, chemical and biological societies, and has received several honorary degrees including an M.D. degree from the University of Heidelberg.

J. N. BRØNSTED, professor of physical chemistry at the Physical-Chemical Institute of the University of Copenhagen, Denmark, is interested at present in problems having to do with the theory of acids and bases, and acid and basic catalysis, as well as the general theory of solutions.

PAUL KARRER, of Zurich, has confined his research during recent years chiefly to the pigments of plants and the vitamins. In connection with his work on the carotinoids he took up the question of the purification and constitution of vitamin A, and succeeded in preparing it in a highly purified state and also in elucidating its chemical constitution to a considerable extent. He has recently started some investigations on vitamin C.

RICHARD WILLSTÄTTER, formerly professor of chemistry at the University of Munich, is now carrying on private research in the laboratories of the Bayerische Akademie der Wissenschaften at Munich. He was Nobel Prize Laureate in chemistry in 1925. He celebrated his sixtieth birthday in 1932. From 1893 to 1910 Dr. Willstätter worked upon alkaloids, from 1904 to 1910 on quinones, later on the benzene theory, catalytic hydrogenation using

platinum, experiments to convert cellulose into sugar, investigations on chlorophyll, and the isolation of a series of pigments from flowers. Since 1918 he has been conducting investigations on enzymes, using the method of selective absorption based on the work of A. Danilewski, and in studies on efficient adsorbing substances, such as the different hydrates of aluminum. Dr. Willstätter, as has already been announced in SCIENCE, has been selected by the Chicago Section of the American Chemical Society to receive the Willard Gibbs Medal September 13.

SCIENTIFIC NOTES AND NEWS

THE Penrose Medal of the Society of Economic Geologists was presented to Dr. Louis De Launay, French mining engineer, at the annual dinner at the Princeton Inn on July 7. Dr. B. S. Butler, of the University of Arizona, president of the society, was in the chair, and Charles Le Ganissel received the award on behalf of Dr. De Launay, who was unable to be present.

AT a recent meeting of the Georgia Section of the American Chemical Society the Herty Medal for 1933 was presented to Dr. Fred Allison, professor of physics at the Alabama Polytechnic Institute, for his work on magneto-optics.

THE Rainer Medal of the Society for Zoology and Botany at Vienna has been conferred on Dr. Paul Buchner, professor of zoology at Breslau.

DR. F. G. DONNAN, professor of general chemistry in the University of London, has been elected an honorary member of the German Bunsen Society.

AMONG those on whom the degree of doctor of laws was conferred by the University of Glasgow at the end of June were Professor Albert Einstein, Léon William Collet, professor of geology in the University of Geneva, and Dr. William Blair Bell, professor of obstetrics and gynecology at the University of Liverpool.

INDIANA UNIVERSITY has conferred the degree of doctor of laws on Dr. Oscar Riddle, of the Carnegie Institution, and on Professor Chancey Juday, of the University of Wisconsin.

THE degree of doctor of science was conferred on Dr. Linus Carl Pauling, assistant professor of theoretical chemistry at the California Institute of Technology, at the sixty-fourth commencement exercises of the Oregon State Agricultural College.

AT the commencement exercises of Ohio Northern University the honorary degree of doctor of science was conferred on Dr. J. M. Rogoff, associate professor of experimental medicine at Western Reserve University.

DR. WILMER KRUSEN, president of the Philadelphia College of Pharmacy and Science, received the honorary degree of doctor of science at the commencement exercises of Franklin and Marshall College.

DR. EDWIN GRANT CONKLIN, who retired last month as Henry Fairfield Osborn professor of biology at Princeton University, has been requested by the board of trustees to serve as lecturer in biology next year.

A UNITED PRESS dispatch states that Professor Albert Einstein will cooperate in the administration and direction of the physics institute of the Hebrew University at Jerusalem. Dr. Einstein is reported to have sent a cable to the effect that he would accept a chair at the university if certain reforms he suggested were carried out.

THE Galton chair of eugenics in the University of London has been filled by the appointment of Dr. R. A. Fisher, who since 1919 has been engaged in scientific research in the statistical department of the Rothamsted Experimental Station. He succeeds Dr. Karl Pearson, who has been Galton professor and director of the Francis Galton Laboratory for National Eugenics since its establishment.

THE Governing Body of the Imperial College of Science and Technology has elected to Imperial College fellowships the following old students of the college: Emeritus Professor P. F. Frankland, Emeritus Professor Henry Louis, Sir Basil Mott and Dr. A. E. H. Tutton.

AT the University of Leeds, E. A. Spaul, of Birkbeck College, University of London, has been appointed professor of zoology and Dr. E. R. Flint has been made director of surgical research.

DR. E. L. MILOSLAVICH, formerly associate professor of pathological anatomy at the University of Vienna and later professor of pathology and director of the department of pathology and bacteriology at Marquette University, Milwaukee, has been appointed professor of legal medicine and director of the Medico-legal Institute at the Royal University, Zagreb, Jugoslavia.

ARNO B. CAMMERER, associate director of the National Park Service, has been appointed director to succeed Mr. Horace M. Albright, who resigned voluntarily to become vice-president and general manager of the United States Potash Company, operating mines and refineries at Carlsbad, New Mexico. Arthur E. Demaray, senior assistant director of the National Park Service, has been appointed associate director.

ELISHA A. VOSE, of Concord, New Hampshire, who has reached the age of seventy years, will retire from the U. S. Weather Bureau on August 1, under the thirty-year service economy rule of the government. Llewelyn Raplee, in charge of the Hartford station, will also be retired.

BRIGADIER ERNEST ELLIOT BUCKLAND MACKINTOSH has been appointed director and secretary of the Science Museum, South Kensington, in succession to Colonel Sir Henry Lyons, who is retiring in October next, on attaining the age of sixty-nine years. He was appointed to his present position in 1920, having previously served in the museum as secretary to the Advisory Council and as a keeper, and his term of office has twice been extended past the normal retiring period. The museum has been greatly extended during his period of office, and he has introduced such novelties as the Children's Gallery and the wireless concerts.

DR. E. W. MACBRIDE, professor of zoology in the Imperial College of Science and Technology, London, has been appointed chairman of the Advisory Committee on Fishery Research of the Development Commissioners, in succession to the late Professor G. C. Bourne.

THE Board of Scientific Directors of The Rockefeller Institute for Medical Research announces the promotion of Dr. Cornelius P. Rhoads from the rank of associate to that of associate member; the appointment of Dr. Theodore J. Abernethy as resident physician at the Hospital of the Rockefeller Institute, and the acceptance already recorded in SCIENCE by Dr. Lawrence R. Blinks, associate in the division of general physiology, of an appointment as associate professor of plant physiology in the department of botany at Stanford University.

DR. VAN B. HART, extension professor of farm management at the New York State College of Agriculture, Ithaca, has been appointed acting director of agricultural extension during the six months' absence of L. R. Simons.

DR. THOMAS E. PURCELL, of Kansas City, has been appointed dean of the School of Dentistry of St. Louis University.

DR. WILBUR F. POTTER, assistant professor of physiology and pharmacology in the Medical Department of the University of Georgia, has been appointed to a similar position at Georgetown University School of Medicine, Washington.

LEAVE of absence for the next academic year has been given by Princeton University to Professor Charles H. Smyth, Jr., of the department of geology. Dr. William T. Thom, Jr., associate professor of geology, has been granted leave of absence for the first term.

PROFESSOR MERRITT F. MILLER, of the Missouri College of Agriculture, has sailed from New York to spend a year in studying soil formations and soil management in Europe.

PROFESSOR H. A. SIMMONS, of the department of mathematics of Northwestern University, who is on sabbatical leave this semester, spent two months in study at Princeton and will be abroad until fall in France, Germany and Italy.

DR. AUGUSTE PICCARD, of the University of Brussels, sailed for France on July 6. Dr. Piccard came to the United States in connection with the stratosphere flight from Chicago, which may be made on July 15 by Dr. Jean Piccard and Commander T. G. W. Settle.

THE Peking correspondent of the London *Times* reports that Dr. Sven Hedin has received news from Dr. Nils Ambolt, the Swedish astronomer who had been missing in Chinese Turkestan for more than six months. Dr. Ambolt is safe at Khotan and is returning to Peking *via* India.

THE twenty-eighth quarterly meeting of the Entomological Club of Southern California was held in June at the University of California at Los Angeles, with an attendance of ninety-one members. The following newly elected officers were installed: *President,* A. W. Swain; *Vice-president,* S. E. Flanders; *Secretary and Treasurer,* H. C. Lewis. The retiring officers were: *President,* C. E. Bliss; *Vice-president,* D. W. Tubbs; *Secretary and Treasurer,* A. M. Boyce. Following the program, consisting of five papers with discussions, the group inspected the laboratories and other facilities of the recently established division of the branch of the College of Agriculture in Southern California at the University of California at Los Angeles.

THE International Society of Orthopedic Surgery, whose president is Professor Nové-Josserand, of Lyons, will hold its second congress in London from July 19 to 22.

THE twenty-seventh South African Medical Congress will be held at Capetown, from September 25 to 30.

WE learn from *The British Medical Journal* that a congress of hydrology will be held at Toulouse in October under the presidency of Professors Sabatier and Abelous. The subjects to be discussed are: the thermo-mineral waters of the French Pyrenees and their geological grouping; the rarer gases of mineral waters; climatic cures and pulmonary tuberculosis; indications for providing treatment for children in

spas, mountain resorts and at the seaside; primary non-suppurative infection of the nervous system in relation to hydro-mineral therapy; utilization of spas by the French army, and the legal control and survey of mineral waters. Sir James Purves-Stewart will contribute a report on infections of the nervous system. After the congress four days will be devoted to motor car tours in Languedoc, Pyrenees and the Côte d'Argent. Further information may be obtained from Dr. François Françon, Aix-les-Bains.

THE Fourteenth Exposition of Chemical Industries will be held in New York in the Grand Central Palace, during the week of December 4. The number of exhibitors, and the progress of the exposition generally, at this date, is equal to the progress in any of the more prosperous years. It is somewhat better, at a corresponding date, with respect to the last exposition, which was held in 1931. Three floors of Grand Central Palace are reserved for the event and, at this date, contracts have been signed which take care of two floors and part of the third. In the most prosperous days, the number of exhibitors at this time has been no greater in proportion.

DR. LINSLY R. WILLIAMS, director of the New York Academy of Medicine, issued the following statement on July 8: "Many physicians engaged in teaching and research in Germany have been deprived of their civil rights so that it has been impossible for them to continue their activities in either of these fields. They have also been deprived of means of support for themselves and their families. Many non-Aryan physicians in Germany have made notable contributions to medicine in teaching and research and German medical science in general has always had many ardent followers in the United States. It is impossible to believe that the present policies, which are doing so much harm to German science and culture, will have the lasting approval of our many German colleagues, with whom we wish to maintain the most cordial and friendly relations." The statement has been signed by a large number of physicians, including Dana Harlow Brooks, Lewis A. Conner, William Darrach, A. R. Dochez, Eugene F. DuBois, John A. Hartwell, G. Canby Robinson, Peyton Rous, James J. Walsh and Shirley W. Wynne. The explanation is made that although many of the signers are affiliated with various medical organizations, their signing of the statement should not be taken as officially representative, but simply as their personal view.

IT was stated in the issue of SCIENCE for May 12 that the works of Dr. Franz Boas, professor of anthropology at Columbia University, had been removed from the library of the University of Kiel, from which university Professor Boas received the doctorate degree in 1881 and was last year given an honorary degree. We are informed from the office of the rector of the university that the books by Professor Boas were not removed from the library but were withheld from circulation for a few days as a protest against an open letter to President von Hindenburg which was signed by Professor Boas.

DISCUSSION

INTERNAL CHROMOSOMAL VARIATION AND ITS PROBABLE CAUSE

IT has been known for some time that in the mosquito there exists a very interesting chromosomal condition. In the cells of all the tissues the nuclei and the cells themselves are of different dimensions, and corresponding to this situation there are parallel differences in chromosomal equipment. The present writer has found this situation in other cases among insects, notably in the blackfly. Not only does this remarkable condition exist in insects, but it has been found quite generally in the case of plants, for example, in the genera Nicotiana and Crepis. This state of affairs also presents itself in so-called graft hybrids and in chimeras.

It has occurred to the writer in connection with a wide series of investigations covering both plants and animals that an explanation of this remarkable situation might be supplied by a study of the meiotic or reduction division. The blackfly and the mosquito were chosen for this purpose and it has been observed that in the active larvae of both these types there are very interesting conditions present in the primary spermatocytes. At metaphase certain smaller chromosomes of the type which it is customary at the present time to designate univalent (a singularly unfortunate appellation!) lag notably on both sides of the equatorial plate. As is commonly the case in animals and lower plants, these chromosomes ultimately reach their proper place in the metaphase plate. In anaphase the abnormal distribution of the chromosomes is still more marked, particularly in the mosquito, where they cover the spindle from end to end in an extremely aberrant fashion. The only reasonable explanation of this situation in accordance with our general knowledge at the present time is the presence of interspecific hybridism. This suggestion is in line with what we know of the cytology of chimeras and internal heteroploidy. In the orange and apple, for example, which are notoriously prone to the forma-

tion of chimeras, the reduction division is strikingly abnormal and the product of pollen is largely sterile. It seems reasonable to suggest in this connection that the internal variation of chromosomal equipment in cells of the same organism where it is present is the result of previous crossing of species. Into this connection should be brought, according to the present writer's investigations, as yet largely unpublished, the clonal or bud variations of types like the Boston fern. On account of the large number of very small chromosomes in the Boston fern, it has been impossible to correlate its innumerable variations with any chromosomal basis; but if there is a reliable foundation to the chromosomal hypothesis of heredity, the very numerous abnormalities appearing as bud sports in the Boston fern must have a heterochromosomal basis.

It is suggested in accordance with this brief summary of conditions in the case of forms which show a high degree of internal variability that heterozygosis or crossing affords a reasonable explanation, as it obviously does in the case of species which vary individually, that is, produce a wide series of different types from the sowing of seeds.

E. C. JEFFREY

HARVARD UNIVERSITY

DISTRIBUTION OF LEAFY SPURGE (EUPHORBIA VIRGATA) IN THE UNITED STATES

LEAFY spurge is a perennial weed that is proving to be one of the most difficult weeds to eradicate. Recent correspondence with botanists and agronomists in agricultural experiment stations and with curators of herbaria has led to the assembling of some important facts that will be of interest to plant workers throughout the country. It is important to locate primary infestations of this weed so that eradication or control measures may be taken at once.

Leafy spurge is listed in the manuals and weed bulletins as *Euphorbia esula* L. According to recent identifications and correspondence received from Herbert Groh, botanist, Department of Agriculture, Ottawa, Canada; P. C. Standley, Field Museum, Chicago; P. Aellen, Basel, Switzerland, and C. V. Morton, Smithsonian Institution, Washington, D. C., it appears that the correct name is *Euphorbia virgata* Waldst and Kit. instead of *E. esula*. C. V. Morton wrote that he was preparing for *Rhodora* a taxonomic note which will give reasons for the change in name.

The present distribution of leafy spurge, so far as the writer has been able to ascertain, is shown on the map (Fig. 1). Each dot represents one or more localities in which the weed has been found. In some cases the infestation may cover many acres, in other cases the weed may be rare. The earliest record found was

FIG. 1. Map of the United States showing present distribution of leafy spurge. Each dot indicates one or several neighboring infestations.

an herbarium specimen bearing as part of the label, "Essex Co., Mass., 1842, Wm. Oakes." The states in which infestations appear to be most serious at present are Minnesota, North and South Dakota and New York. It appears to have only recently invaded the states of Wisconsin, Iowa, Illinois, Nebraska, Colorado, Montana, Idaho and Washington. So far, there appears to be no record of its presence in Oregon, Utah, Wyoming, Kansas, Missouri, Kentucky, Ohio, Virginia, Delaware, Rhode Island, Vermont, or in other states south of those now showing infestations.

Undoubtedly, leafy spurge has a wider distribution than indicated on the map. In the state of Washington it is known that it is more wide-spread than shown by the single dot, but definite records do not seem to be available now for other localities. In West Virginia it appears that it was collected there last summer, but definite information is not yet available.

It is to be expected that leafy spurge will appear sooner or later in Middle Western and Western states adjoining the states that now show infestations. Judging from present indications it appears possible that leafy spurge will become a serious weed over a wide area extending from New York to the state of Washington and as far south so as to include Oregon, Utah, Kansas, Missouri and Kentucky.

HERBERT C. HANSON

NORTH DAKOTA AGRICULTURAL EXP. STATION

THE TYPE OF THE GENUS LECANIUM

IN SCIENCE for August 9, 1929 (p. 150), I discussed the type of this important genus of scale insects, and referred to Kirkaldy's indication of *L. hesperidum* (L.), 1906, as being earlier than the designation of *L. persicae* (Fab.) by Sanders in 1909. I had quite forgotten that I myself explicitly designated *L. hesperidum* as the type in *Entomologist,* 1901 (p. 91).

T. D. A. COCKERELL

UNIVERSITY OF COLORADO

AMERICAN SCIENCE

SINCE returning to India two and a half years ago I have had many opportunities of discussing American achievements in science, especially in the domain of biology and agriculture with several Indian men of science. Many of these men, who have been to Great Britain and Germany for advanced training, are connected with the universities, colleges, agricultural or scientific institutions. The opinion expressed by a majority of them relative to American scientific work was that much of it was "spurious," "no scientific value," "will have to be carefully repeated," "take with a ton of salt all that comes from the New World," etc. Having worked in or visited many of the best scientific institutions in the United States, I was not only surprised but pained to hear such disparaging remarks. When I have pressed these men to point out instances of spurious work or when I have brought under their notice some of the fine researches that have definitely advanced knowledge, I have found that the prejudice in several cases was not based on any facts. Indeed some of these men, when a new problem turns up for solution, especially in the field of the agricultural sciences, go to American literature for guidance, while some others are busy investigating problems which have long ago been successfully solved in America.

I think that much of the prejudice is because the people here can not realize the extent of facilities and funds available for scientific work in America. An American scientist, interested in a problem, works all day and far into the night. He subscribes liberally to journals in which he is interested and reads a great deal not only in his own but collateral sciences. He very frequently attends scientific association or academy meetings so as to meet and exchange thoughts with others working along similar lines. He is ever on the alert to advance in the subject of his choice, and on his achievements depends his future. In India things are different. Funds and facilities are meager. The scientist is appointed to hold a "permanent position," which he relinquishes only after he reaches a certain age. If he is in a particular "cadre" he gets his annual salary increment irrespective of meagerness of scientific output. Those in the lower rungs of service who may be doing well have few chances of advancement because of rules of service and various other causes.

Scientific societies are few and the annual meetings are not well attended unless the universities or the government departments meet the "traveling allowances" of these men of science. Personal subscriptions to science journals is a luxury indulged by very, very few, indeed.

A third reason for the belief that American science is cheap is, perhaps, the American generosity in distributing "literature." Some of the experiment stations and other institutions send their bulletins, memoirs, etc., for the mere asking. The spirit behind this, in several cases that I know of, is an honest desire to help and for the spread and dissemination of knowledge. This is mistaken here for American "boosting." Many of the distributed bulletins have only local value, such as those reporting varietal trials or manurial tests or, say, those reporting the trend of prices of hogs as correlated to corn yields. Some stations send not one or two but four or five of the same bulletins. No wonder files of these in library corners come to be known as American trash. It is only when a publication is extremely inaccessible or rare that its value advances. It is the duty of an investigator to search and find out literature, rather than for an experiment station to bring it to the notice of workers the world over.

It is time for the experiment stations to revise their free distribution policy, especially in these depression days, and help also in acquiring proper recognition for American science.

"TAXILA"

INDIA

SPECIAL CORRESPONDENCE

MALNUTRITION IN THE AMAZON BASIN

ONE of the very interesting observations made during the recent magnetic expedition, August, 1931, to January, 1933, in South America, by the writer for the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, concerns the distribution of malnutrition in the Amazon Basin. While this matter has nothing to do with the prime purpose of the expedition, attention is called to it, since it may be of great interest to organizations that are concerned with the study of human life and settlement in the tropics.

It has long been pointed out by Stefansson and a number of other Arctic men that the civilizing influence of missions and Hudson's Bay Company stations is not entirely beneficial to the Eskimo. The reason is that malnutrition and deficiency diseases, which seem never to be found among these people as long as they live by their own hunting mode of existence, generally make their appearance as soon as

the Eskimos begin to barter furs, etc., for the food supplies brought north by the white men. In this connection, Dr. William A. Thomas, working with the 1926 MacMillan expedition, made a health survey of the Eskimos of Greenland and Labrador. His report, published by the American Medical Association, states that those Eskimos who have close contact with traders, "whose meat is cooked and whose diet includes many prepared, dried, and canned articles," are very subject to both scurvy and rickets, while those Eskimos who live their native life of hunting and fishing, with a carnivorous diet, mainly raw, show no tendency toward either of these diseases.

A somewhat analogous condition was observed on this recent field-trip, but has never, as far as I am aware, been reported by any other observer.

In this memorandum, reference is entirely to the "white" settlers in the regions concerned, meaning by that the non-Indian inhabitants, who generally lead a life far different from that of their Indian neighbors.

The Alexander Hamilton Rice Expedition to the Rio Branco, 1924–25, made a medical survey of that region, and reported malnutrition, due to the lack of fresh food in the diet of the settlers, as being one of the greatest fundamental detriments to health. This was confirmed by the writer, as far as a non-medical observer may dare to confirm the reports of a medical expedition. I believe, however, that even a lay traveler is justified in linking the almost universal lethargy of the inhabitants of a region with his own lethargy and his own inability to obtain fresh food.

The same condition was seen on the Brazilian Rio Negro, where health conditions were bad, the white settlers nearly always obviously listless and whining, and where there was the greatest trouble in getting anything to eat except beans, rice, dried meat and dried fish.

One curious fact, however, was very noticeable. The Venezuelan-Brazilian border on the Rio Negro seemed to draw a sharp line of division between two "health regions." On the Venezuelan Rio Negro and on the Orinoco as far as Puerto Ayacucho, the settlers were evidently much more active and much more inclined to laugh and "get a kick out of life" than on the Brazilian side. At the same time, while I also had difficulty in getting food on the Orinoco and upper Rio Negro, it was almost impossible there to obtain any kind of dried or preserved food such as beans, rice or dried meat. The only articles obtainable that were not fresh were mandioca and cassava bread. Everything else was invariably fresh, such as corn, bananas, pineapples, live chickens, yucca and live turtles.

It seems reasonable, therefore, to conclude that the settlers on the Venezuelan side of the border owe their better health conditions to better nutrition, and the corresponding absence of deficiency diseases.

This condition can in no way, however, be ascribed to a difference in personal tastes between the Venezuelan and the Brazilian settlers. It must, I believe, be ascribed to the fact that the Brazilian government shows a greater amount of concern for its "out-of-the-way" regions than does the Venezuelan government for those in Venezuela.

The Venezuelan Orinoco and Rio Negro are entirely abandoned to-day as far as regular commercial transport is concerned. Commerce in these regions is dead, except for a small amount of balata and some few Tonka beans. The result is that most of the settlers here export nothing and can import nothing. Most of those who lived there a few years ago have emigrated by now, but the few remaining ones are forced to plant, hunt and fish in order to stay alive. Agriculture among the white settlers is far more prevalent to-day than it was in the days of the rubber boom and is a direct result of the withdrawal of "civilization."

On the Brazilian Rio Negro, however, there is at least one steamer or launch every month, between Manaos and the garrison-town of Cucuhy, on the border. This makes commerce possible, and most of the settlers on the river still engage in trade—in balata, Brazil nuts and palm fibers. They pay almost no attention to agriculture, getting the major part of their food from Manaos in dried and preserved form, since no ice is to be found anywhere on the river. The result is malnutrition.

In justice to the Brazilian government, however, it must be said that the seriousness of the situation is fully realized. A great deal of money has lately been spent at Barcellos, in clearing land for an enormous plantation, to be run in sections by the local inhabitants under government supervision. The ultimate success of this, however, depends on the price of rubber. If the latter rises a few cents, it is probable that the citizens of Barcellos will abandon their plantation and run into the jungles for rubber.

The sub-prefect of Barcellos, a medical student, recognizes the seriousness of malnutrition among his people. At the time of my visit he had applied to the government at Manaos for permission to import three live steers a month, to be butchered at Barcellos, so the inhabitants can have some fresh meat. I had some interesting discussions with him about this, since in my opinion the method was hardly adequate. The probable result of such a step would be that the people would obtain their precious meat, dry it and hoard it for Sunday use. However, the importation of foods by the government would hardly tend to stabilize the population. It would have seemed much

better to import a number of the Indian water-buffalo that do so well in the jungle regions of the lower Amazon, and get the inhabitants to breed the animals themselves.

However, any such step would have to be accompanied by education in the desirability of fresh meat against dried. It is noticeable that on the ranches of the great fertile cattle plains of Brazilian Guiana, where over 200,000 head of cattle are grazing to-day, fresh meat is almost unobtainable, and the problem of malnutrition is every bit as serious as on the jungle rivers. Vegetables seem never to be planted. Meat is very seldom eaten fresh. The reasons for the latter are threefold. In the first place, the ranchers are used to dried meat and possibly prefer it to fresh. Their diet is extremely limited in scope. This would probably make it all the more difficult to induce them to change and enlarge it—Stefansson has very forcibly pointed out that men as well as dogs who are used to a limited diet find it much more difficult to take to any change than those who are already used to a great variety. In the second place, the absence of ice makes it impossible to preserve meat in a fresh state after a steer has been killed, and would result in a large amount of wastage unless the meat were dried. In the third place, the population in these regions is so scattered that any "community" solution of the problem would be impossible. Every ranch is a small and self-contained community in itself, and the butcher-shops that are found in the town of Boa Vista can not exist in the cattle plains.

The river turtles and fish that give the inhabitants of the river settlements a certain amount of fresh food in units small enough to prevent wastage are, of course, lacking on the cattle plains. Whether or not chickens are cultivated in the cattle lands to any extent is something I am not able to say. On the two ranches that I visited, they were not to be found.

One other matter, that may be of interest in connection with the problem of diet and dental caries, might well be mentioned here. In Manaos I met Mr. Desmond Holdridge, of the Brooklyn Museum, who had with him a Makuxi Indian boy called Moi-i. This boy had lived for some fifteen years with his tribe, living the usual native tribal life. Here he had never known or seen any signs of dental decay. He had found it necessary, however, at the age of fifteen, to leave his tribe and to establish himself as a hired hand on the Brazilian National Ranch in the cattle plains. After a year and a half there, he came to Manaos with Holdridge, where the latter found it necessary to take him to the dentist to repair the ravages of a bad case of caries. This was told to me by Moi-i, and confirmed by Holdridge, who had known the boy well when he first left his tribe.

Inquring about the changes of diet, etc., that had accompanied this change in dental health, I found the following to have taken place. While living with his own people, Moi-i had eaten a great many fresh vegetables of various kinds, a good deal of hard cassava bread, little meat and almost no salt. On the ranch, living with white men, he had eaten a great deal of meat, mainly dried and salted, also milk, cheese, etc., almost no vegetables and a great deal of salt. The point about salt is interesting in view of the fact that the Indians of Southern Venezuela seem to believe that the white men have bad teeth because they eat so much salt. Moreover, while living with his own people, Moi-i had had the habit of constantly cleaning his teeth with charcoal, a habit that he had dropped when he went to live with the white man.

The matter throws an interesting light on the widespread modern idea that our teeth are bad because our soft foods do not give them enough exercise. While with his own people, Moi-i had found plenty of exercise for his teeth, in chewing the hard cassava bread. Here they stayed healthy. But later, when he lived with the white man, he had to chew still harder in order to get down the quantities of dried meat. If exercise is the determining factor, his teeth should have improved instead of deteriorating.

EARL HANSON

WASHINGTON, D. C.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

SAVINGS IN LABORATORY EXPENDITURES WITHOUT LOSS OF EFFICIENCY

WITH the present decreases in budgetary appropriations it has become a necessity for investigators to secure results with cheaper equipment. Notable savings can be accomplished by simple adaptations of common marketable supplies which are used for domestic purposes.

Operating tables for animal work can be readily adapted from kitchenware departments at a cost which is one tenth of the fancy professional models. Operating lamps, 110 volt, (particularly of the large Zeiss or Leitz types) can be equipped with 100 watt Mazda, instead of the costly filament types, without great loss of efficiency. Six volt lighting equipment can readily be modified to take automobile lamps, sometimes at an increased efficiency and generally at one tenth of the cost.

Sterilization can be secured just as readily with a

pressure cooker costing $15.00 as with the larger standard autoclave. Hot air sterilization can be efficiently and effectively completed in an ordinary baking oven with ordinary bunsen burners as the heat source. Fractional sterilization equal to the Arnold can be secured in a large-sized double boiler, by perforating the bottom of the enclosed utensil. Many of our fancy electrical set-ups can be efficiently made from radio equipment. Rheostats, potentiometers and meters are available at small cost. They must be calibrated, but then so should the more costly material from the supply houses.

The care of small animals is generally a very costly and inefficient process. In many cases the larger the animal the more the wastage. Small rodent colonies are useful for many types of work, but frequently are too costly to maintain on an adequate scale for continuous work. The cost of an attendant where the colony is of large size is no small item. If a part-time assistant can be used for this work, a larger saving can be effected. If a full-time assistant is available, part of his time can be used for other things demanding time without interruption.

As a standard stock feed for rats and mice, the dog and fox chow marketed by the Purina Company has many advantages over the ones usually used. It can be purchased in reasonable quantities, is easily stored in galvanized iron cans, keeps until used. The animals do not tire of it and it seems to be a complete diet under our laboratory conditions. This food is cheaper than any special baking brand which we have so far secured. It is supplemented with lettuce (3 times per week) and with stale bread, both of which can be obtained cheaply. Many complex drinking bottles are available, most of them costly. We use a 16 ounce Whitall-Tatum bottle with an L tube which leads to the cage interior. The L tube is fitted to the bottle with one inch of pressure tubing used instead of the usual perforated rubber stopper. The bottle is fastened to the top or side of the cage with a brass spring, preventing dislodgement and breakage. Cleanliness of an animal room is one of the most completely neglected of the arts. If all metal cages are used and supported 18 inches above the catch pans, which are covered with sawdust, the cages keep much cleaner than is the case where they are directly on the sawdust base. We use single plane sheets of aluminum for the catch pan. This can be scraped and washed in a few minutes. Our routine calls for complete cleaning operations three times each week. This is a minimum for a reliable rodent colony.

The wastage usually is more excessive in the operating room than in the animal colony. Ether for anesthesia is wasteful of this reagent as well as of animals under the methods generally employed. Narcosis is seldom satisfactory, and often the work must be hurried because of the animal's condition. Sodium amytal (Lilly) is an efficient, reliable and cheap method of settling the expense of narcosis. Antiseptic solutions often serve as irritants or astringents as used in animal work. Sterile 5 per cent. borax solution or chlorozene is just as effective as the more costly proprietary solutions. Clips so necessary for the suturing of skin incisions are usually the baby-skin clips used in human surgery. A metal stapling plier, H-54, distributed by the Hotchkiss Sales Company (Stamford) can readily be adapted as a skin suturing device by sawing 5 mm from the fixed jaw on the lower side and removing the lower part of the cover of the upper jaw.

The above are just a few of the economies which can be used to reduce the costs on most colonies from 40 to 60 per cent., without impairment of efficiency.

J. S. NICHOLAS

OSBORN ZOOLOGICAL LABORATORY
YALE UNIVERSITY

SPECIAL ARTICLES

THE STORAGE SAC FOR CAPSULE REINFORCEMENT IN NERITIDAE

ONE hundred years ago, when Qouy and Gaimard included in their multitudinous findings of the voyage of the *Astrolabe* (1830–1933) the discovery that the snail, Nerita, is not hermaphrodite, they figured and described two problematical organs of the female—the one a sac accessory to the uterus, containing white limey objects thought to be eggs; and the other a pyriform organ containing elongated filaments. Speaking of their illustrations, they recommended those who desire to understand the usage of organs to give special pains to the verification of what is represented of the reproductive organs.

In 1857, a student of Johannes Mueller, Eduard Claparede, having made a detailed study of the anatomy and development of the fresh-water snail *Neritina fluviatilis* near Berlin, was not able to clear up either of the above two problematic organs, but upon dissecting specimens of *Nerita peleronta* L., *N. atrata* Chemnitz, and *N. albicilla* L., found in the females that the above uterus accessory sac contained, not eggs, but lime concretions of 100 μ to 500 μ diameter, white and spheroid in the first two species, but red brown and discoid in the last, from the Red Sea.

While he described in detail the eggs of *N. fluviatilis* as laid in capsules often covered over with shells of diatoms, he surmised that in Nerita limey capsules

might be made by the accessory sac in the breeding season, but that the sac at other times might deposit its excess of lime as these remarkable concretions. Still the organ was problematical. "Die Bedeutung des Organs ist hoechst räthselhaft."

Comparative study of several Neritina and Nerita organs and egg capsules had made it evident that the pyriform organ is concerned with the holding and dissolution of large, remarkable spermatophores, while the sac accessory to the uterus has, as surmised by Claparede, a use in connection with the egg capsule but only as a reservoir for such hard mineral objects as are to be incorporated into the roof of the capsule. The spermatophore disposal will be considered elsewhere. The evidence that the accessory sac of the uterus is used as storage for reinforcements to the capsule is briefly presented here.

Dissecting one hundred *Neritina reclivata* from Florida, all the 61 females had an accessory sac homologous with that first made known by Quoy and Gaimard in Nerita, but not seen by Claparede in *Neritina fluviatilis,* and in very many cases this sac was stuffed full of minute clear sharp fragments of silica sand, which ran out on puncture of the sac wall, as sand runs in an hour-glass. In June some of these snails laid eggs in many capsules, the top surface of which was thickly strewn with sand agreeing with that in the accessory sac; moreover, the sand found in the rectum along with other indigested material was just like that in the sac.

Apparently, sand taken in with food was selected out and stored in the sac accessory to the uterus. In this species, the rectal reproductive complex has two terminations externally; the one that of the free, presumably protrusible, so-called vagina connected internally with the spermatophore storage and utilization pouch; the other a shallow cloaca-like opening in which discharge not only the uterus or oviduct and its accessory sac, but also the anal end of the rectum. Thus sand may be sorted out from the feces and stored in the sac accessory to the uterus and later passed from this sac to the capsule, which presumably is made in the uterus, that being supplied with remarkable glands producing vesiculated material similar to that of which the capsule is made.

Several other species of Neritinas have the same sac and store up sand which appears upon the roof of the capsules, which differ in different species and in different localities both in shape, size and in amount of reinforcement used.

Dissection of the old alcoholic specimens of *Nerita versicola* from Jamaica showed that the storage sac accessory to the uterus was full of the carbonate of lime concretions known from the work of Quoy and Gaimard and of Claparede, but that there was no evidence of these being made in that sac; on the contrary, almost identical spherulites were found in the ultimate lobules of the liver as if originating there and also scattered in liver ducts. Inferentially these mineral particles originating in the liver are taken out of the rectum and stored in the accessory storage sac to be used at proper season in the reinforcement of the egg capsules. Confirmation of such use was first had on July 13 at South Nigril Point, Jamaica, B. W. I., where just above the breaking surf on the etched limestone of the elevated coral reef *Nerita peleronta* (the bleeding tooth shell) was found on the rocks.

One large specimen in minute pool, 3×5 inches, had apparently long resided in this home depression, in water one inch deep. Near the snail were some 6–9 large 4 mm flat white capsules, which showed, with the pocket lens, the expected lime spherulites all over the surface of each capsule.

Later at White House sands, east of Montego Bay, *Nerita tesselata* was taken along with capsules that proved to be specifically distinct and covered over with pearl-like spherulites.

While *Neritina fluviatilis* was found by Claparede to have generally diatom shells over its capsules, and while several Neritinas show siliceous sand with, seldom, a few diatoms or sponge spicules as reinforcement to the top of the capsule, the above Neritas reinforce the egg capsule with lime spherulites that come from the storage sac as does the sand in the other snails. But in the small *Nerita alticola* Pilsbry, from the rapid waters of the Great River and its branch, the capsules are reinforced not with lime spherulites, but with fine siliceous sand. Is it that in passing from an assumed salt water ancestry, this snail has taken up the collecting of solid particles from its food in place of the hepatic manufacture of reinforcements for the egg capsules? Moreover, Neritinas both in salt and in fresh water are found to use not only silica but limestone fragments, or even a foram shell as reinforcement of the capsule roof.

The plan of these capsules in the Neritidae thus far studied is that of a closed-up box, with thin floor closely applied to the substrate and thus commonly flat but sometimes curved, from which floor there rises up all about an elliptical continuation as a low wall supporting a very large roof more or less convex. *Neritilia succinea,* however, has less specialized spheroidal capsules, very small and simple. The material is a dense secretion at first evidently very soft and sticky but later becoming hard and leather-like. It burns with charring and evolution of fumes like burnt hair and does not dissolve in acid or in

boiling potash. While the floor may show rather large vesiculate structure and the walls and roof very fine vesiculations, it is only the roof that is generally reinforced by many imbedded solid particles. The roof also is joined to the top of the walls with a preformed joint that finally allows the roof to rise up and fall off, leaving the wall to stand as rounded conspicuous white line about the nearly invisible floor for months' duration, after the young have escaped. The roof also may be prolonged laterally as more or less extensive rim or eaves just above the breaking joint; the top of the wall may also be somewhat prolonged laterally under the above named eaves of the roof.

The capsules of different species present differences in size and in outline, but especially in character of the reinforcement of the roof as well in extent or absence of the rim. Moreover, in any one species the capsules vary in size and form according to size of the females making them and differ in nature and size of solid objects used for roof reinforcement according to character of substrate on which the animal feeds in different localities; or even in the same locality, whether on bottom or on floating objects.

However, these capsules of the Neritidae, which are comparable to eggshells of birds and reptiles as being secretions placed about an albuminous mass in which one or more ova have been placed, may aid in classification.

E. A. ANDREWS

JOHNS HOPKINS UNIVERSITY

RESPIRATORY INFECTION IN EQUINE ENCEPHALOMYELITIS

EQUINE encephalomyelitis has been transmitted to two horses by single instillations of 50 cc of Berkefeld filtered virus into the nostril. The stock strain of virus used was originally obtained from the brain of a horse which was killed when prostrate with encephalomyelitis during the epidemic in Western Nevada in September, 1931. This strain of virus has been maintained by routine passage through guinea-pigs and horses for the past eighteen months.

For inoculation of the horses, a one per cent. Locke's solution emulsion was prepared with the brain and liver virus from three guinea-pigs. This was allowed to extract at 5° C. for three hours, with occasional agitation. The virus emulsion was then centrifuged and filtered through Berkefeld N filters (7 to 8 lb. test) and the filtrates pooled. Aerobic and anaerobic cultures made from the filtrates did not show any bacterial growth during ten days' incubation. The pH of the pooled filtrate was 7.2.

Fifty cubic centimeters of the Berkefeld filtered virus was instilled into one nostril of a horse. Seven days later, this horse showed a temperature of 105° F. and marked congestion of the conjunctiva. Definite symptoms of encephalomyelitis were present on the tenth day; namely—depression, incoordination and receding fever. Motor paralysis and prostration occurred on the eleventh day, when the animal was sacrificed for humane reasons. The virus was subsequently demonstrated in the brain of this horse by inoculation of guinea-pigs.

The second horse was inoculated with the same strain of virus recaptured from the first horse by guinea-pig passage, guinea-pig brain virus being used. The same experimental conditions were duplicated, namely, the method of preparing the virus emulsion and filtration.

Horse number two received 50 cc of Berkefeld filtered virus in one nostril. Six days later this horse had a temperature of 104° F. On the seventh day, the temperature was 105° F. and accompanied by profuse nasal discharge and congestion of the conjunctiva. On the eighth day depression and preparalytic symptoms appeared, the temperature receding to 103.8°. Motor paralysis, amaurosis and prostration occurred on the ninth day, when the subject was destroyed. Virus was recaptured from the brain and cord by guinea-pig passage.

As controls on each of the two intranasal infection experiments, guinea-pigs and another horse were injected intracranially under anesthesia with the same Berkefeld filtered virus. All the control guinea-pigs developed characteristic symptoms of encephalomyelitis and either had died or were destroyed by the fifth day.

The two control horses injected intracranially with virus developed typical symptoms of encephalomyelitis on the sixth day after injection. One was prostrate on the eighth day and was destroyed. The other lingered until the twelfth day, became prostrate and was sacrificed. This individual, being an old horse, presumably had some natural resistance.

The incubation period of the disease in horses which received virus in the nostril was two and three days longer than that following intracranial injection.

Postmortem examination of the two horses which received virus in the nostril showed hemorrhagic infiltration at the base of the brain tending to follow the olfactory tract and extending posteriorly to the piriform lobes. The spinal fluid in one instance was very turbid and had a large mononuclear count of 680 per cmm. Polyneuclear leucocytes were not observed. Test for sugar was negative.

It appears that inanimate objects, such as feed racks and watering troughs, are not vectors of infection. During the past year one corral has been

used for horses inoculated with virus. Twenty inoculated horses have developed symptoms of encephalomyelitis and either died or were destroyed while in this corral. All new horses were purposely placed in this corral without any sanitary precautions whatsoever, other than removal of manure. The same feed racks and watering troughs were used. No spontaneous cases of encephalomyelitis have occurred and all the presumably exposed horses proved susceptible to intranasal or intracerebral inoculation of virus one to four months later.

The existence of virus carriers among otherwise healthy horses is suspected. In several instances during the past two years, previously unexposed horses have developed typical cases of encephalomyelitis when brought to ranches having a history of encephalomyelitis among the horse population from six to fifteen months prior to the arrival of the new stock, the old horse stock remaining on the ranch not showing any clinical evidence of the disease during the previous outbreak or during the intercurrent period. In one instance all the new arrivals developed the disease in seven to ten days after arrival, while on other ranches one or more new additions developed the disease soon after arrival on the premises.

The period of incubation in experimental horses following intranasal exposure to virus agrees with the reports from practising veterinarians that additional cases of equine encephalomyelitis usually occur in seven to ten days after the first case came to clinical notice.

LYMAN R. VAWTER
EDWARD RECORDS
NEVADA AGRICULTURAL EXPERIMENT STATION, RENO

INHERITANCE OF RESISTANCE TO FOWL PARALYSIS (NEUROLYMPHOMATOSIS GALLINARUM)

ALTHOUGH a number of investigators have reported that fowl paralysis can be transmitted by inoculation, only a comparatively small percentage of the inoculated birds develop clinical symptoms of the disease. Moreover, a certain percentage of the non-inoculated controls also develop fowl paralysis. These facts have rendered the experimental study of this disease very difficult.

In a previous report,[1] data obtained from a spontaneous outbreak of fowl paralysis have been presented. It was found that some families were entirely free from paralysis, while others showed a high incidence of the disease, thus indicating the existence in the domestic fowl of hereditary differences in resistance to fowl paralysis.

In order to obtain further data on this phase of the problem, inoculation experiments were started with chicks from known "susceptible" lines. Approximately one half of the chicks were inoculated at 1 to 7 days of age with emulsions of tissue from paralyzed birds. The inoculated and non-inoculated chicks were kept under identical conditions in the same house. Sixty-three out of 202 chicks, or 31.4 per cent., developed paralysis. There was no difference between the inoculated and non-inoculated groups of chicks in the incidence of fowl paralysis. The post-mortem observations made on some of the paralyzed birds have been described elsewhere.[2]

When the chicks were grouped into families the following results were obtained: four families, comprising 27 chicks, were entirely free from paralysis; eight families, which showed a close approximation to a 1:1 ratio, gave 49 normal to 42 paralyzed chicks; and five families showed a 3:1 ratio (62 normal to 16 paralyzed). No large family of chicks, all of which became paralyzed, was obtained, but in one family of 6 individuals 5 chicks developed paralysis. The chick which did not develop paralysis was killed at 147 days of age.

These results indicate that resistance to fowl paralysis depends upon a dominant gene, and points to the conclusion that in the stock used only one pair of genes is involved. No evidence of sex linkage was observed.

It appears that the proportion of paralyzed to normal birds in any transmission experiment would depend on the genetic constitution of the chicks as regards resistance or susceptibility to fowl paralysis. Hence a genetic analysis of the material is necessary in evaluating the results of fowl paralysis transmission experiments.

JACOB BIELY
V. ELVIRA PALMER
I. MICHAEL LERNER
V. S. ASMUNDSON
THE UNIVERSITY OF BRITISH COLUMBIA

[1] V. S. Asmundson and Jacob Biely, *Can. Jour. Research*, 6: 171–176, 1932.

[2] Jacob Biely, V. Elvira Palmer and I. Michael Lerner, *Can. Jour. Research*. In press.

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